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INVESTIGATION OF THE LONGITUDINAL STABILITY AT HIGH SPEEDS OF A 1/5-SCALE MODEL OF A TAILLESS PURSUIT AIRPLANE

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WASHINGTON

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Air Materiel Command, U. S. Army Air Forces

INVESTIGATION OF THE LONGITUDINAL STABILITY AT HIGH SPEEDS OF A 1/5-SCALE MODEL OF A TAILLESS PURSUIT AIRPLANE

By Edmund V. Laitone

SUMMARY

Tests of a tailless pursuit airplane model at the Ames Aeronautical Laboratory have shown that in conditions corresponding to level flight at a Mach number less than 0.7 and at an altitude under 35,000 feet, no serious compressibility effects occurred and that no sudden adverse diving moments were encountered up to a Mach number of 0.74, the maximum speed of the tests. However, there were indications that the elevons might lose their effectiveness for longitudinal control during a pull-out from a steep dive.

INTRODUCTION

In order to determine the effect of high speeds upon its longitudinal stability and control and at the request of the Army Air Forces, Materiel Command, a 1/5-scale model of a tailless pursuit airplane was tested in the Ames 16-foot wind tunnel. Similar tests were made of the wing alone in order to determine the approximate characteristics of a flying wing.

APPARATUS AND METHODS

The model, made principally of mahogany, was provided with a solid steel wing spar. The general model dimensions are shown in figure 1.

The model was mounted on two support struts in the Ames 16-foot wind tunnel, as shown in figure 1. Figure 2 shows the complete model. Figure 3 shows the wing alone as mounted for tests to determine the approximate characteristics of a flying wing.

RESULTS

The drag, lift, and pitching moments were corrected by deducting the approximate support-strut tares obtained from tests with only dummy booms mounted on the support struts (fig. 4). Figure 1 presents the significant model dimensions. The pitching-moment coefficients were computed for moments about the center of gravity and were based on the mean aerodynamic chord (fig. 1). The drag coefficients were corrected, by standard methods, for the tunnel-wall interference and for the upward inclination of the air stream as evaluated by testing the model upright and inverted. The buoyancy and constriction corrections were neglected, being less than one percent. The data were not corrected for the spanwise variation of the upflow angle or for induced velocities due to the support struts. The approximate spanwise variation of the upflow angle and local Mach number, as shown in figure 5, were determined by measurements made with only the dummy booms mounted on the support struts (fig. 4).

The data were obtained for a Mach number range of 0.3 to 0.74, corresponding to a Reynolds number range of 3,200,000 to 5,700,000 based on the M.A.C. of 1,567 feet. Figures 6 to 18 inclusive, show the variation with Mach number of the drag and pitching-moment coefficients for constant lift coefficients. Figures 6 to 11, inclusive, are for the complete model with various elevon angles (fig. 1), while figures 12 to 17, inclusive, present the results of the wing alone. A positive elevon angle (e) is defined as a downward move-moment of the trailing edge. Figure 18 shows the effect of adding roughness (1/4-inch-wide strip of No. 180 carborundum) at the 10-percent-chord line along the entire span of the complete model.

The general scatter of the test points at high speeds is approximately 0.01 for the lift and pitching-moment coefficients and 0.001 for the drag coefficients.

DISCUSSION

The data indicate that no serious compressibility effects occurred up to a Mach number of approximately 0.7, provided the lift coefficient remained less than 0.4. A Mach number of 0.7 corresponds to a speed of 465 miles per hour at an altitude of 35,000 feet. These conditions require a lift coefficient of only 0.23 for the wing loading of the full-scale airplane, 39 pounds per square foot. Consequently, for conditions corresponding to level flight of the airplane at a Mach number less than 0.7 and at altitudes below 35,000 feet, no large adverse compressibility effects were indicated.

The variation of pitching moment with Mach number for the complete model and for the wing alone was similar to the characteristics of typical wing sections, no adverse diving moments being evident. However, figure 11, for the complete model, indicates that difficulties in longitudinal control may be experienced at high speeds with lift coefficients of 0.4 or more because the elevons ceased to be effective. Figure 11 shows that for elevon deflections of -6° the pitching-moment increment remained appreciable until a Mach number of 0.7 and a lift coefficient of 0.4 were exceeded, then the pitching-moment increment became negligible. Also at a lift coefficient of 0.4 or more and at a Mach number greater than 0.5, elevon deflections beyond -6° were ineffective for longitudinal control. Therefore, some trouble may occur during a pull-out from a steep dive. For example, a 5g pull-out at 506 miles per hour at an altitude of 15,000 feet requires a lift coefficient of 0.47 at a Mach number of 0.7, a condition for which the model test results show the elevons to be relatively ineffective. Figure 17, for the wing alone, exhibits the same general characteristics, showing that the effect was not produced by the addition of the fuselage or duct openings. However, it is important to note that appreciable scale effects may be involved. At the low Reynolds number of these tests (3,200,000 to 5,700,000), the tendency of the flow to separate is probably greater than it would be at full-scale Reynolds numbers. Surface roughness, the effect of which is indicated for the model by comparison of figures 6 and 18, might be of smaller consequence in full scale, since it would probably have less tendency to promote separation. The support booms, which were flush with the inboard ends of the elevons, as shown in figure 1, may have produced interference, especially at the higher lift coefficients and Mach numbers.

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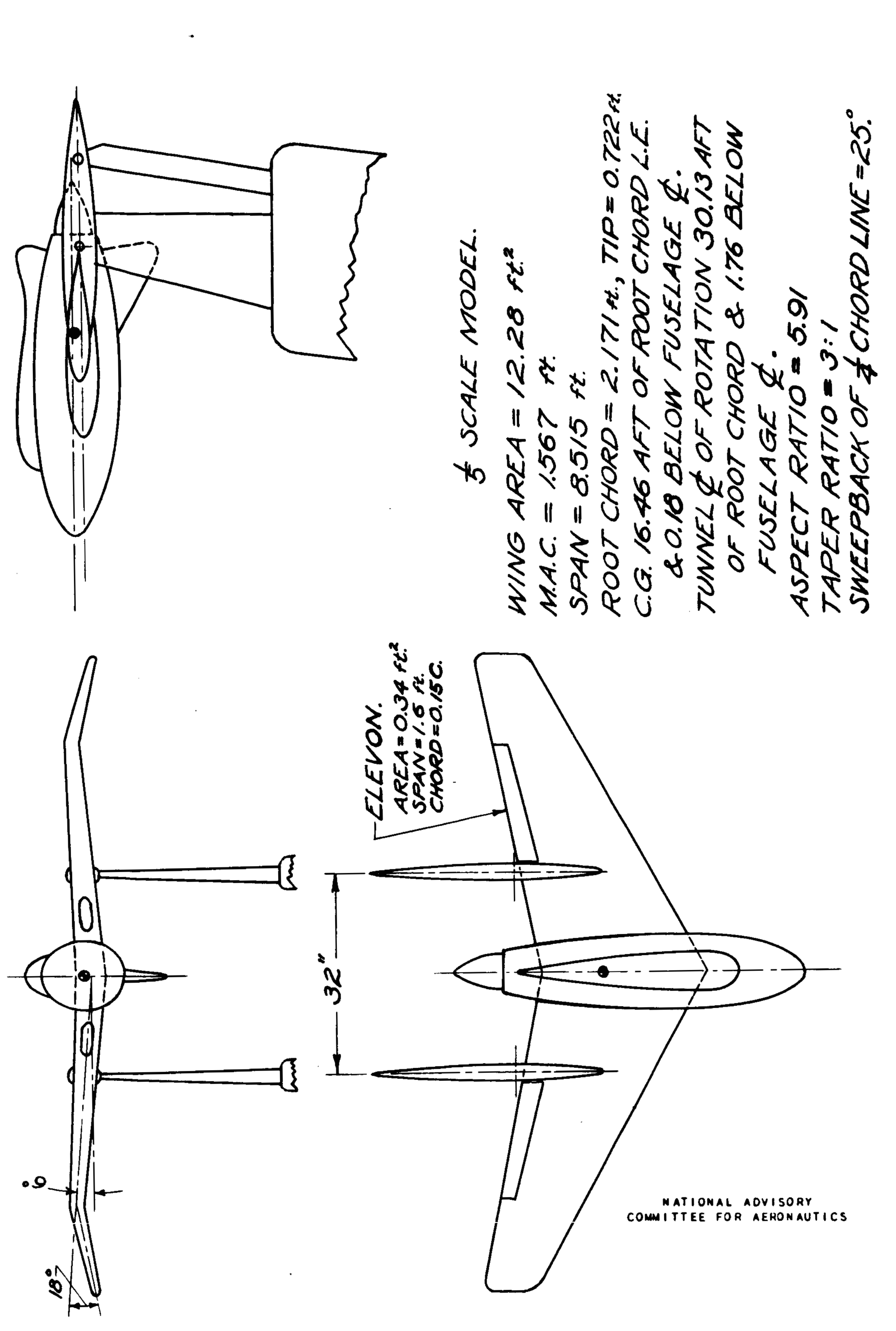

Figure 1.- Outline of the model mounted on support struts.

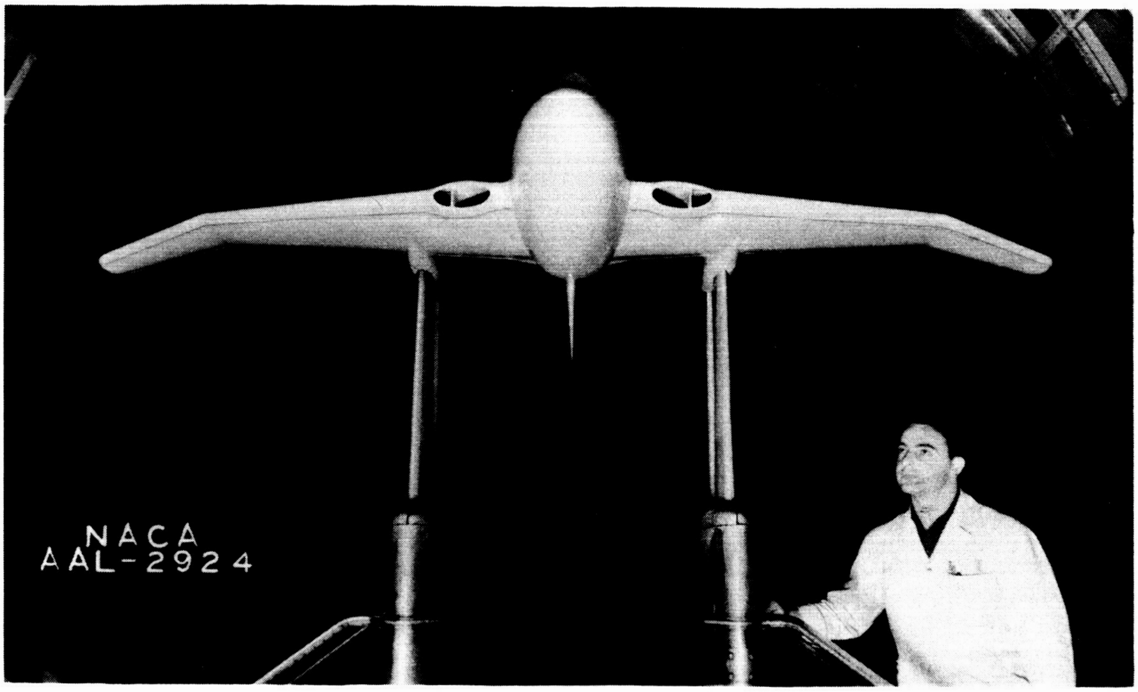

Figure 2.- Complete model.

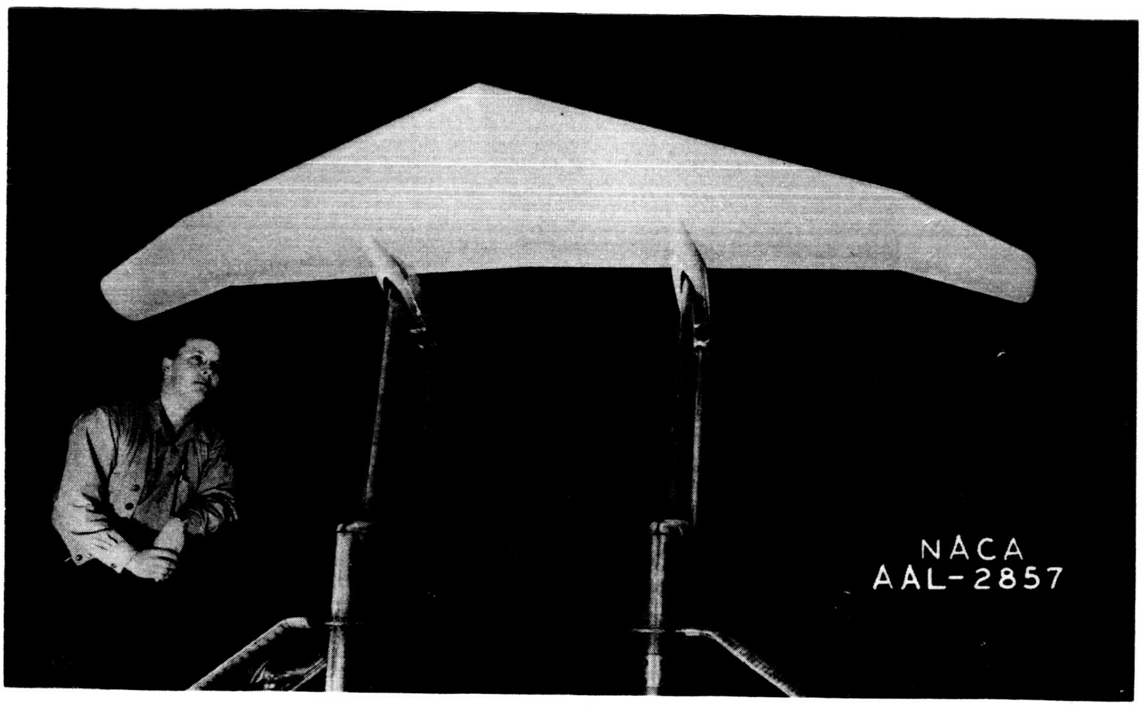

Figure 3.- Wing alone.

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Figure 4.- Dummy booms mounted on support struts

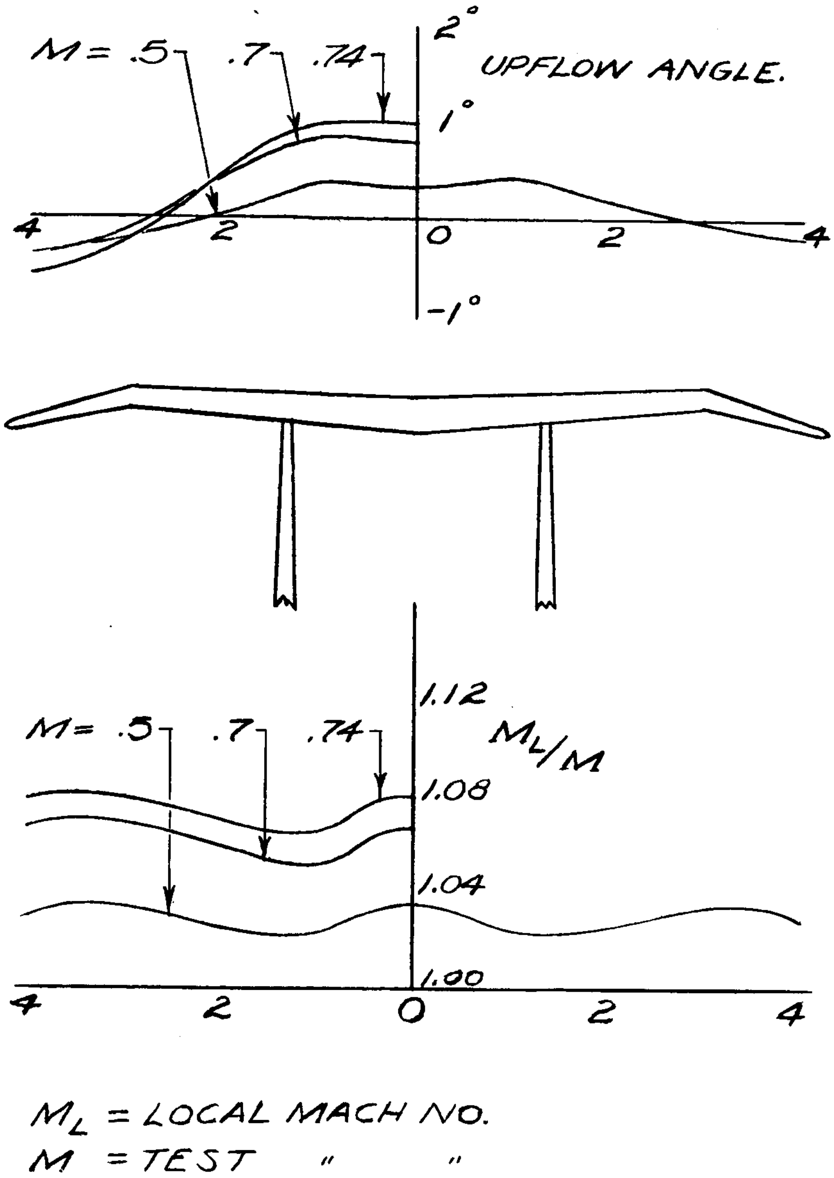

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Figure 5.- Spanwise variation of upflow angle and local Mach number in vertical transverse plane through model center of gravity.

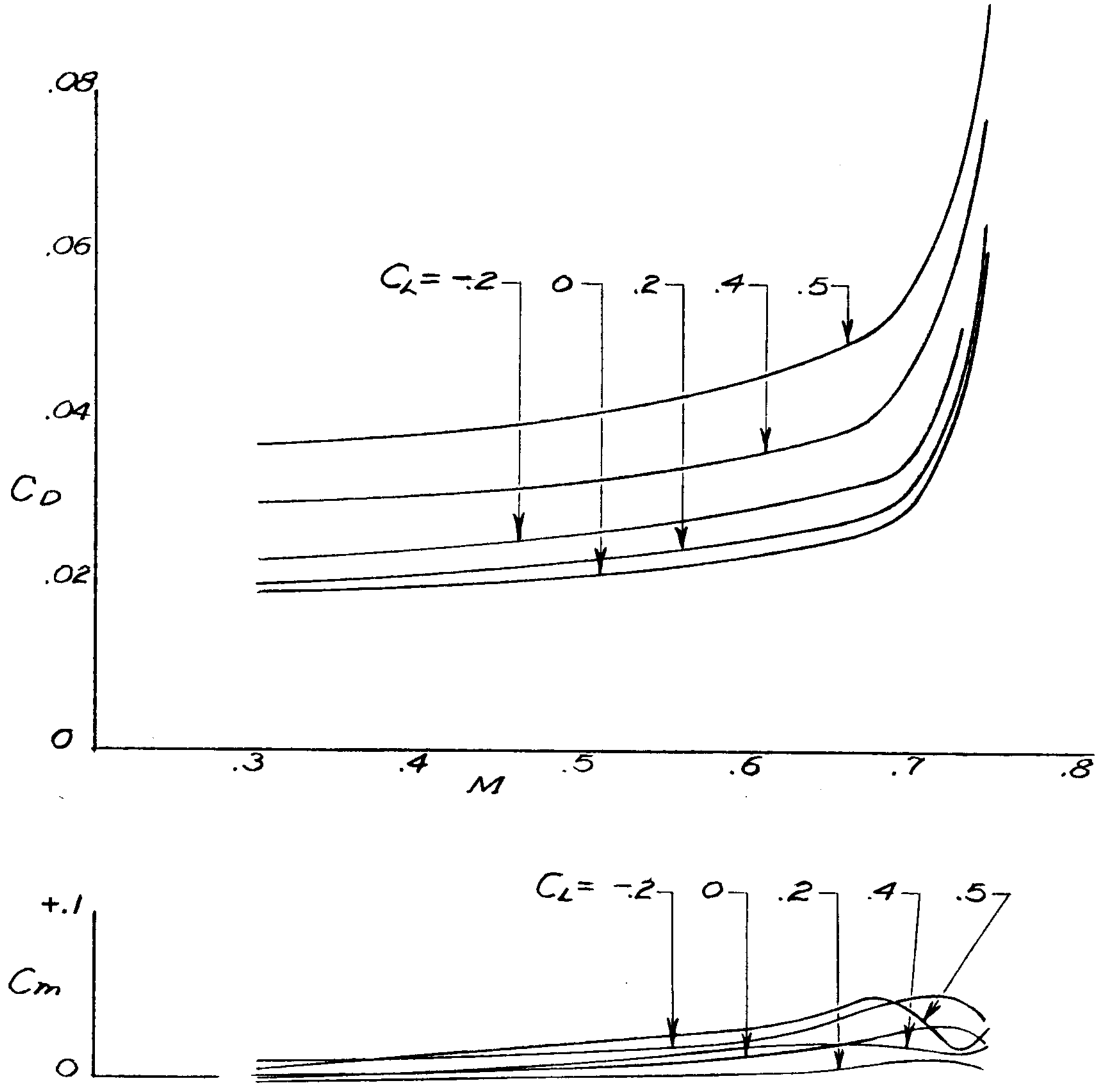

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Figure 6.- Variation of C_D and C_m with M at constant C_L for complete model with elevons at 0°.

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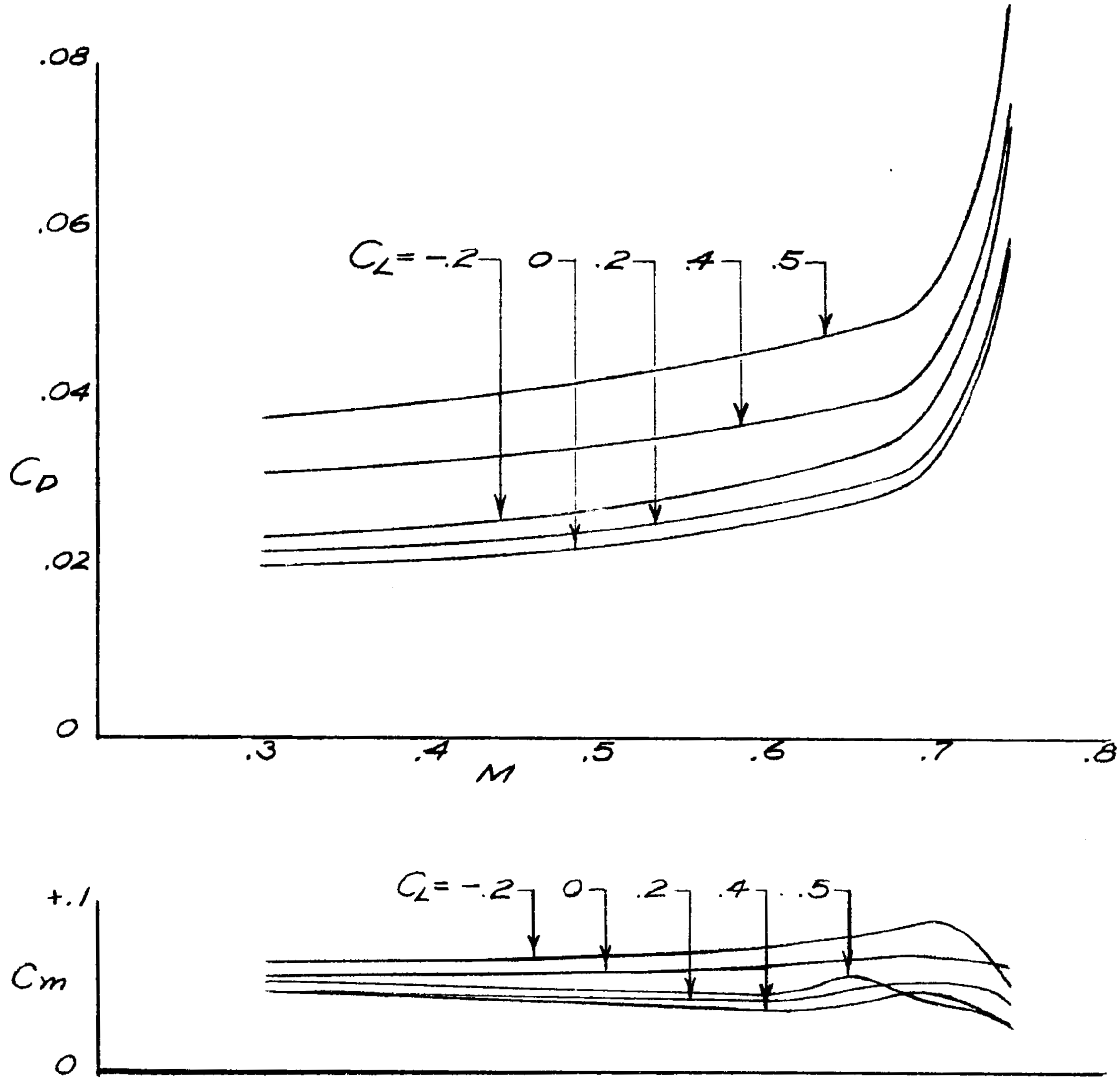

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Figure 7.- Variation of C_D and C_m with M at constant C_L for complete model with elevons at -12°.

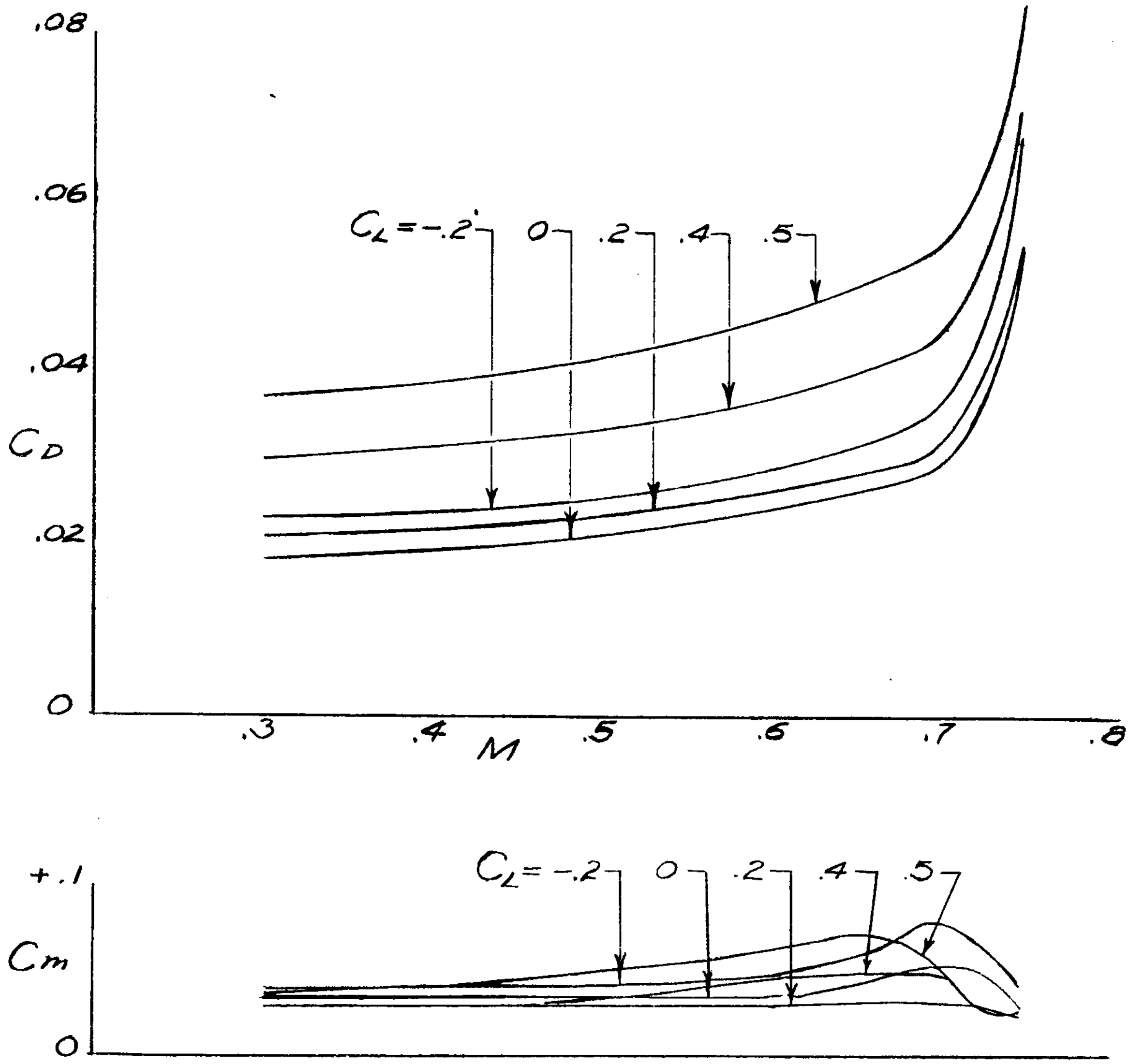

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Figure 8.- Variation of C_D and C_m with M at constant C_L for complete model with elevons at -6°.

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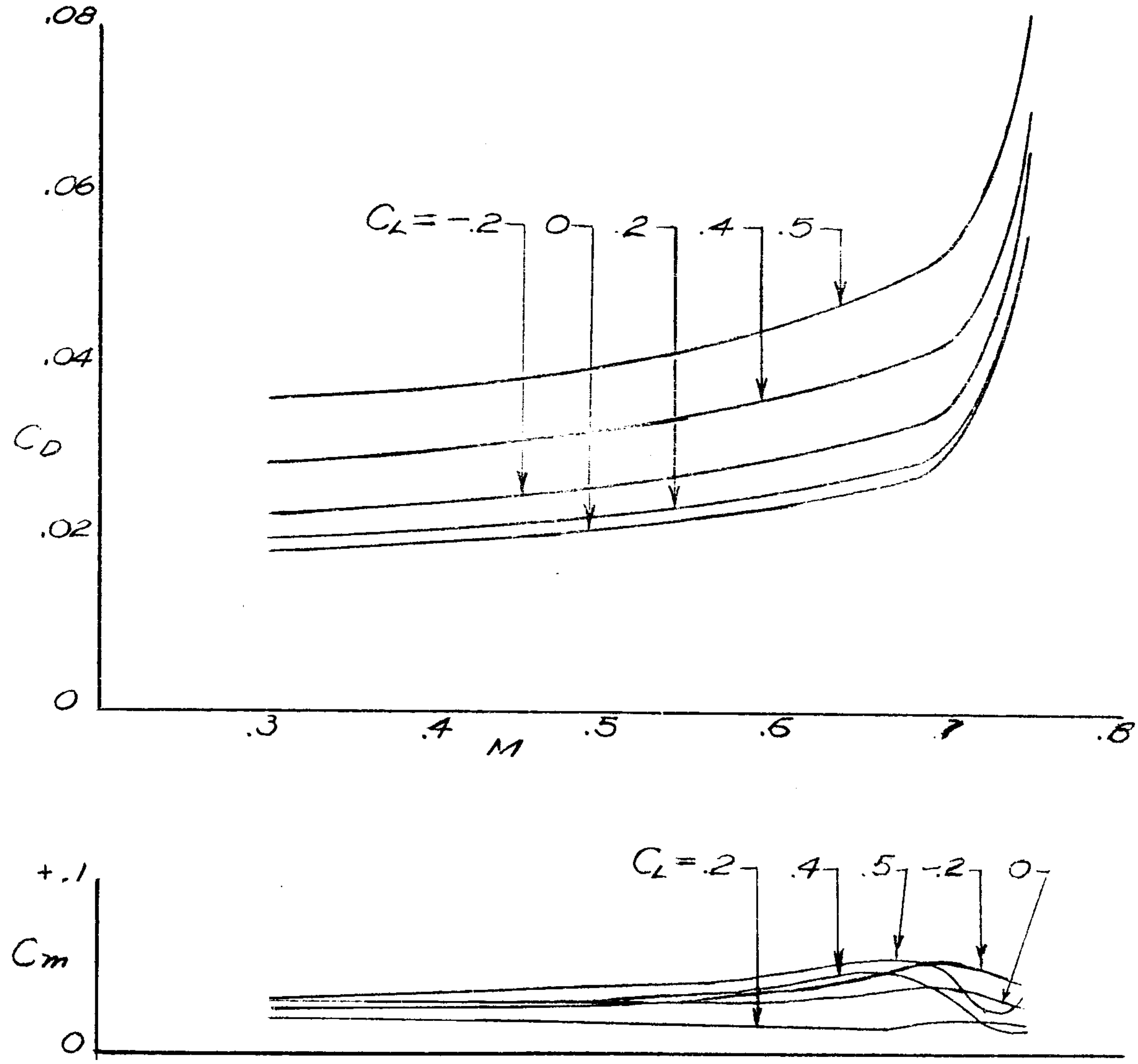

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Figure 9.- Variation of C_D and C_m with M at constant C_L for complete model with elevons at -3°.

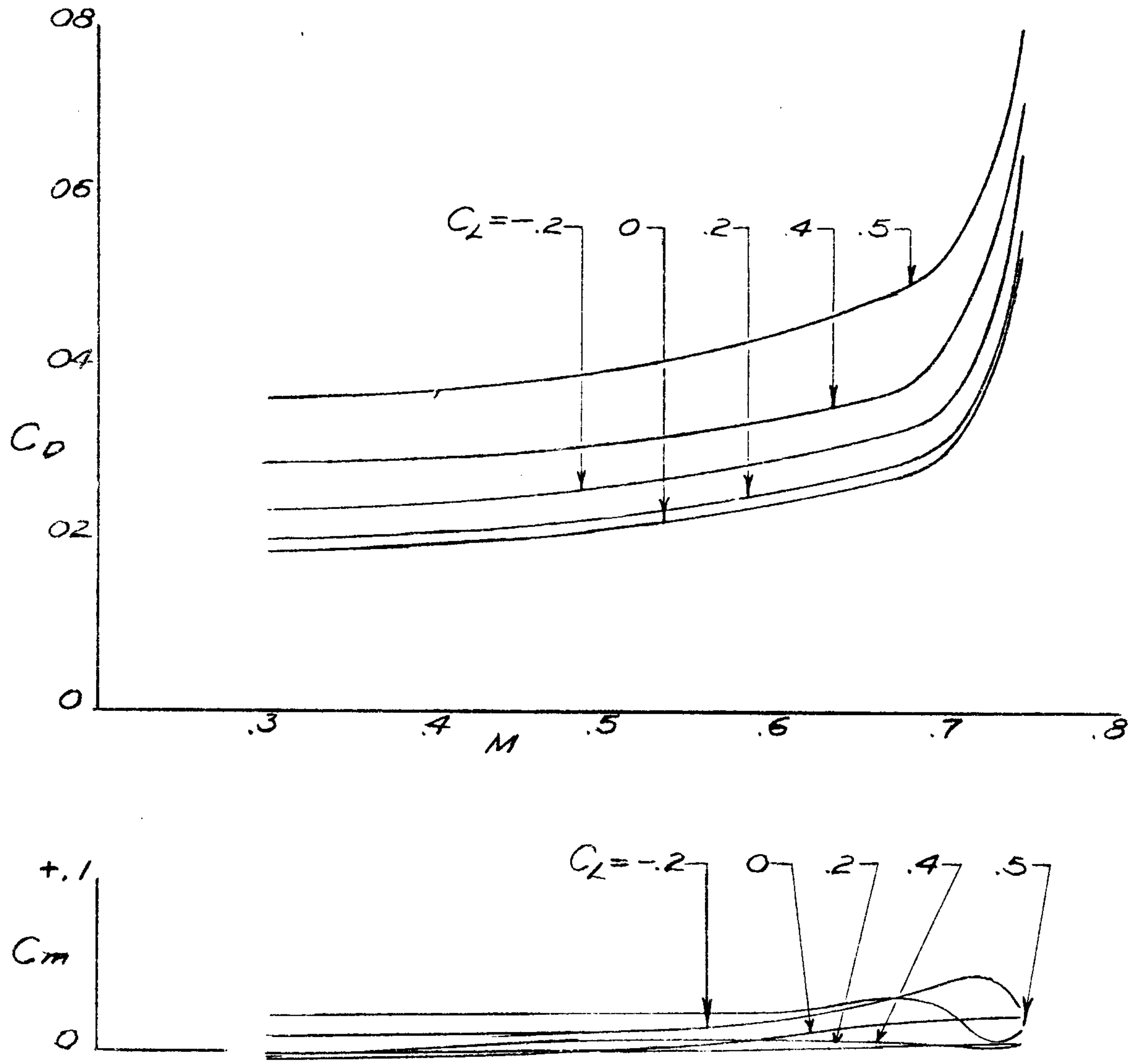

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Figure 10.- Variation of C_D and C_m with M at constant C_L for complete model with elevons at +3°.

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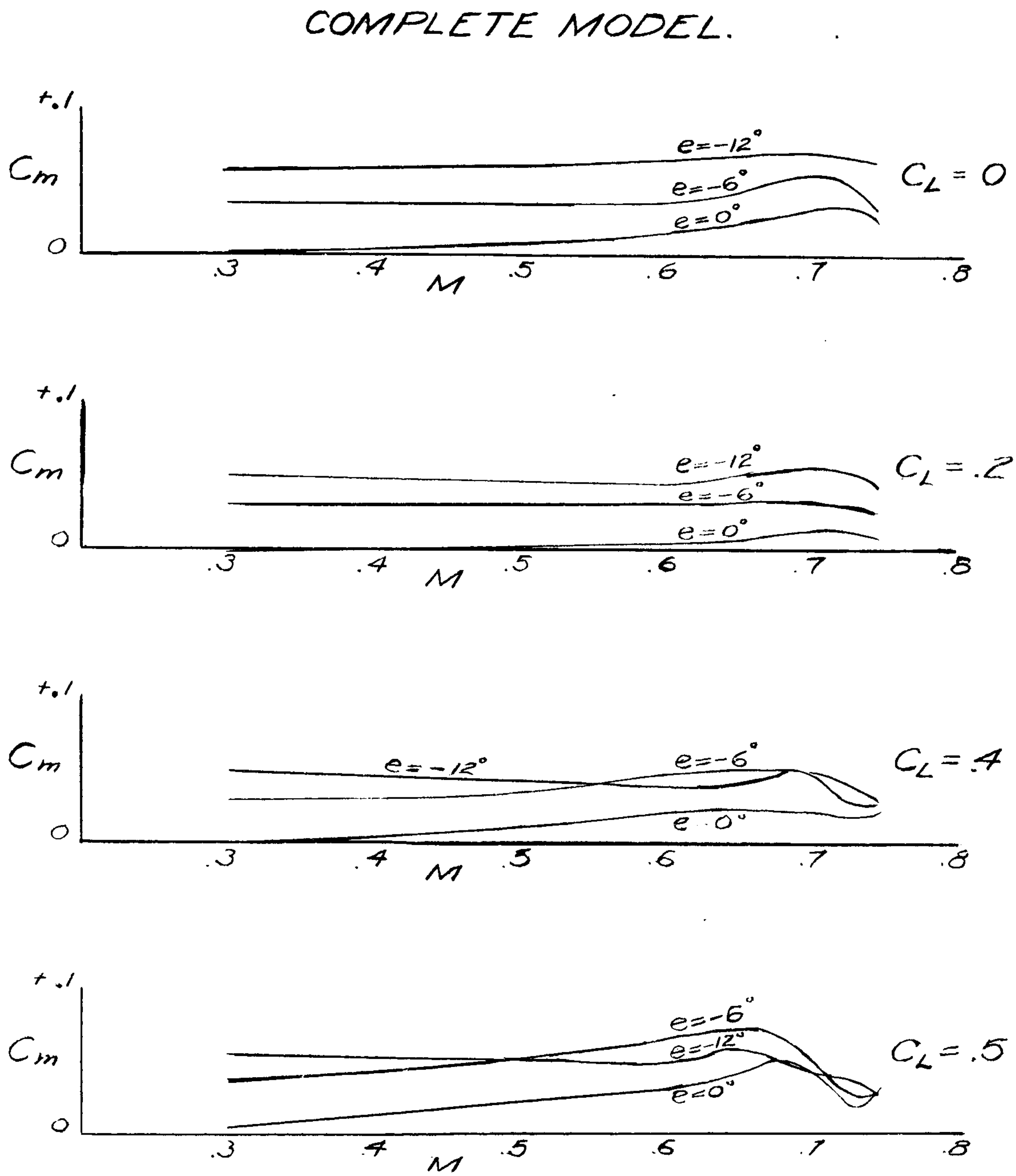

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Figure 11.- Elevon effectiveness for the complete model.

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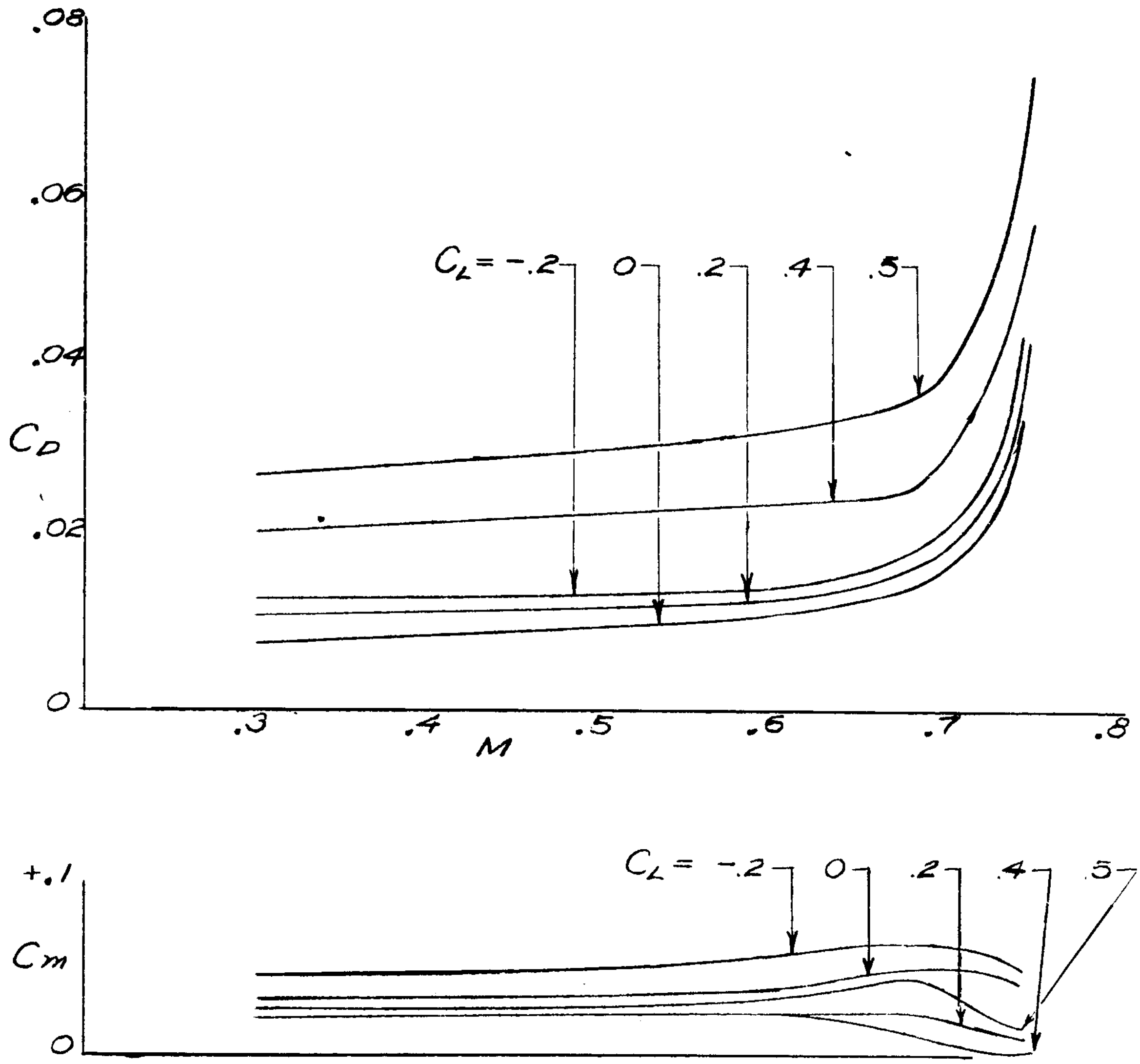

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Figure 12.- Variation of C_D and C_m with M at constant C_L for wing alone with elevons at 0°.

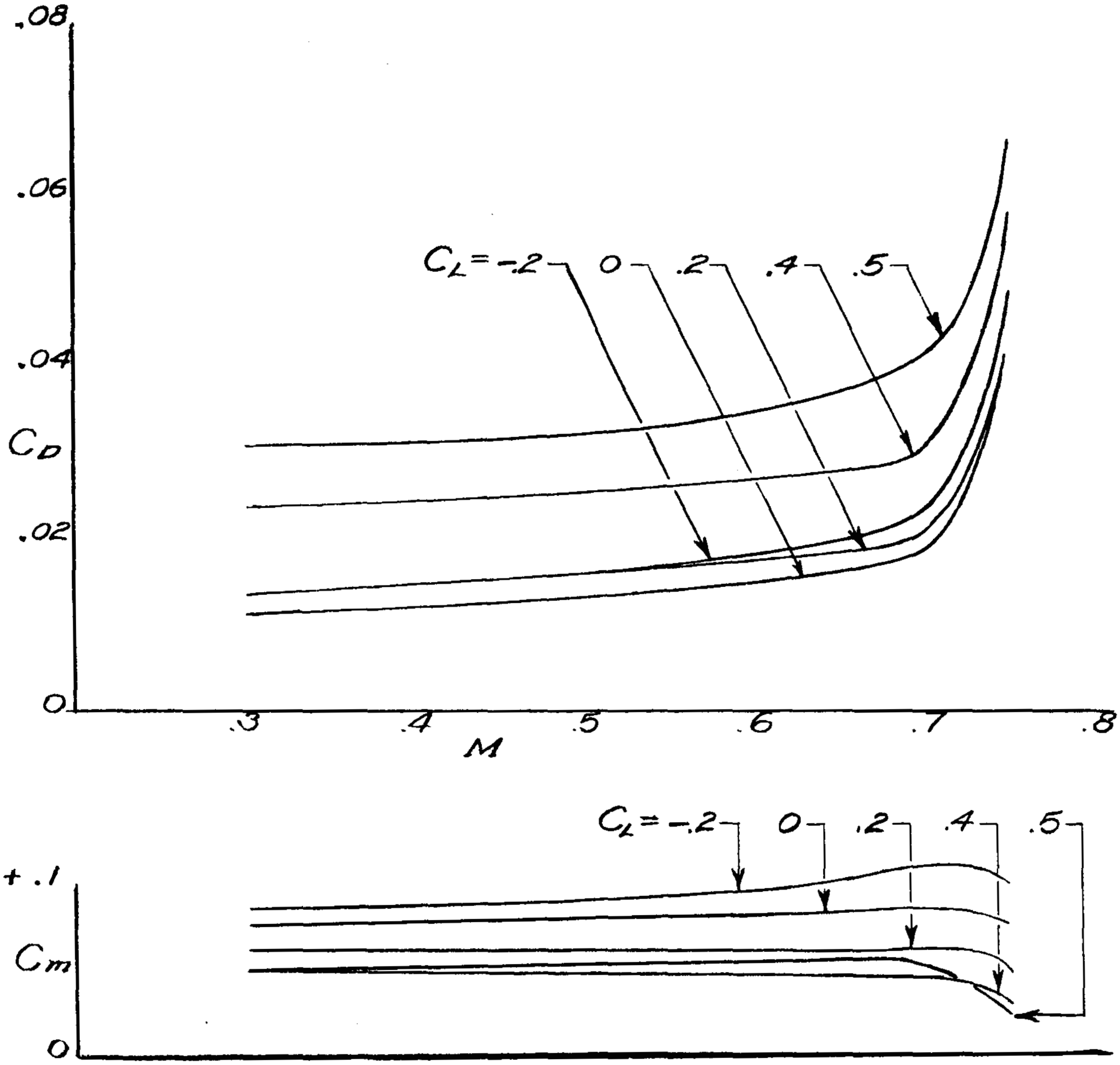

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Figure 13.- Variation of C_D and C_m with M at constant C_L for wing alone with elevons at -12°.

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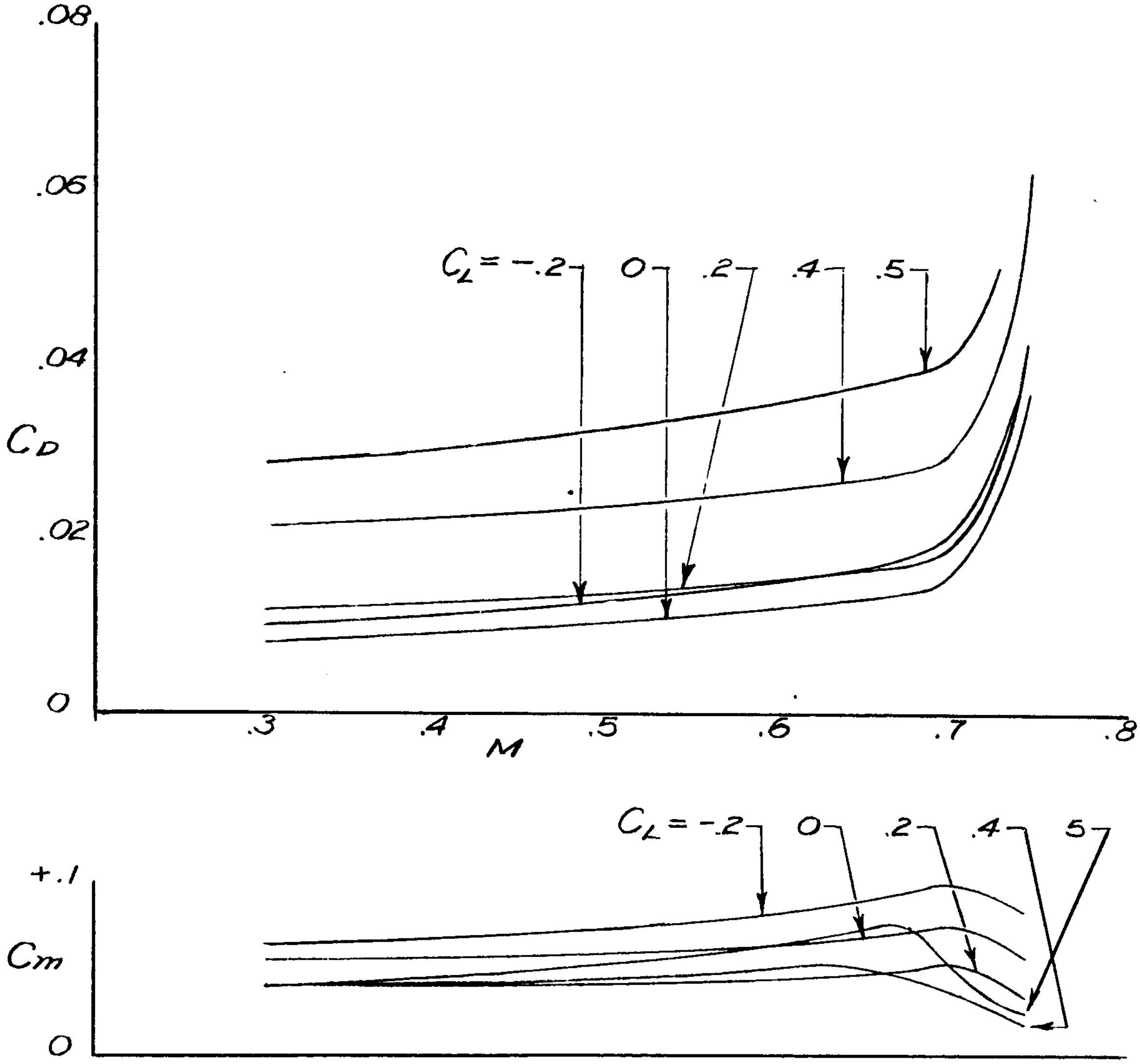

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Figure 14.- Variation of C_D and C_m with M at constant C_L for wing alone with elevons at -6°.

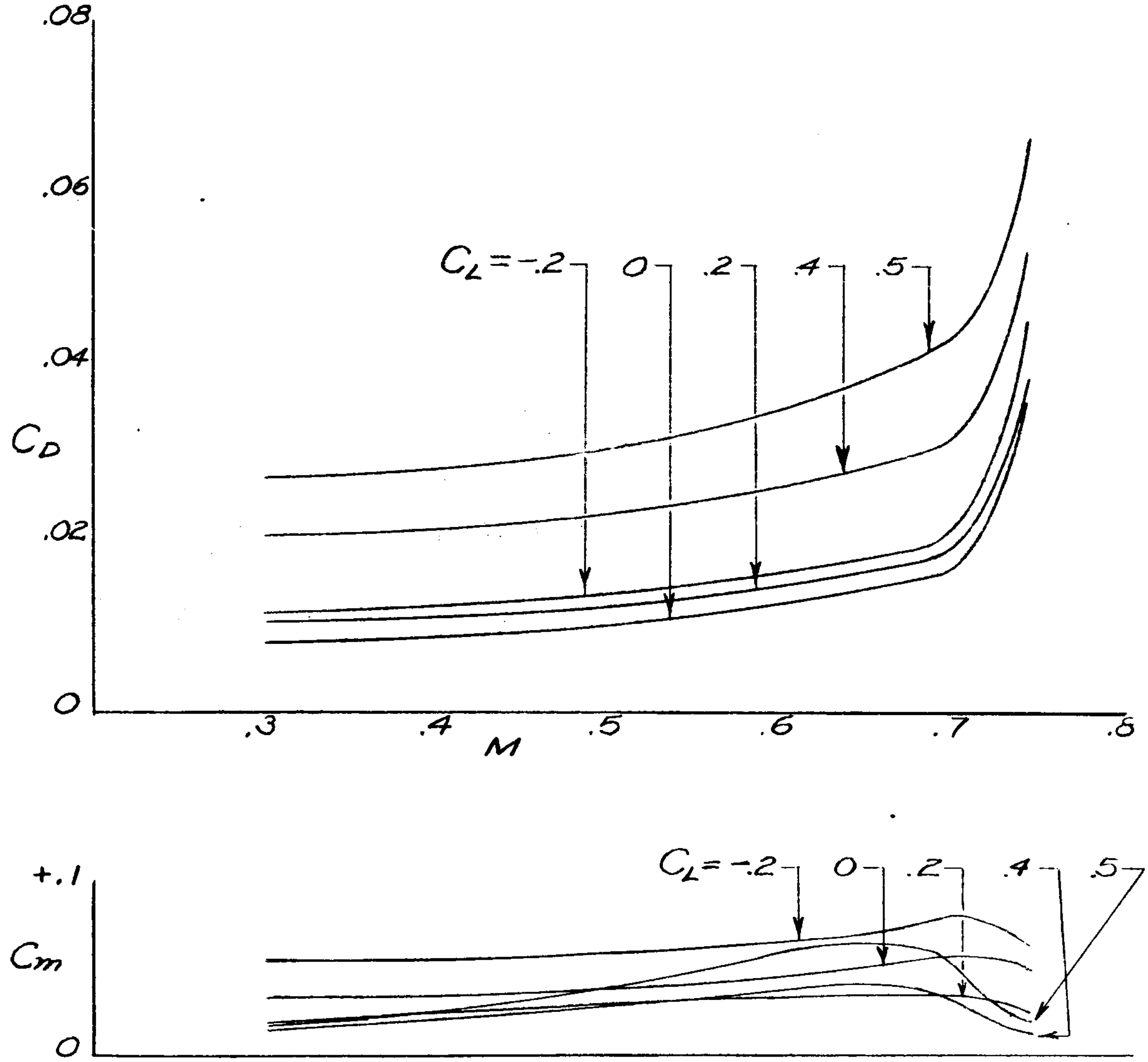

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Figure 15.- Variation of C_D and C_m with M at constant C_L for wing alone with elevons at -3°.

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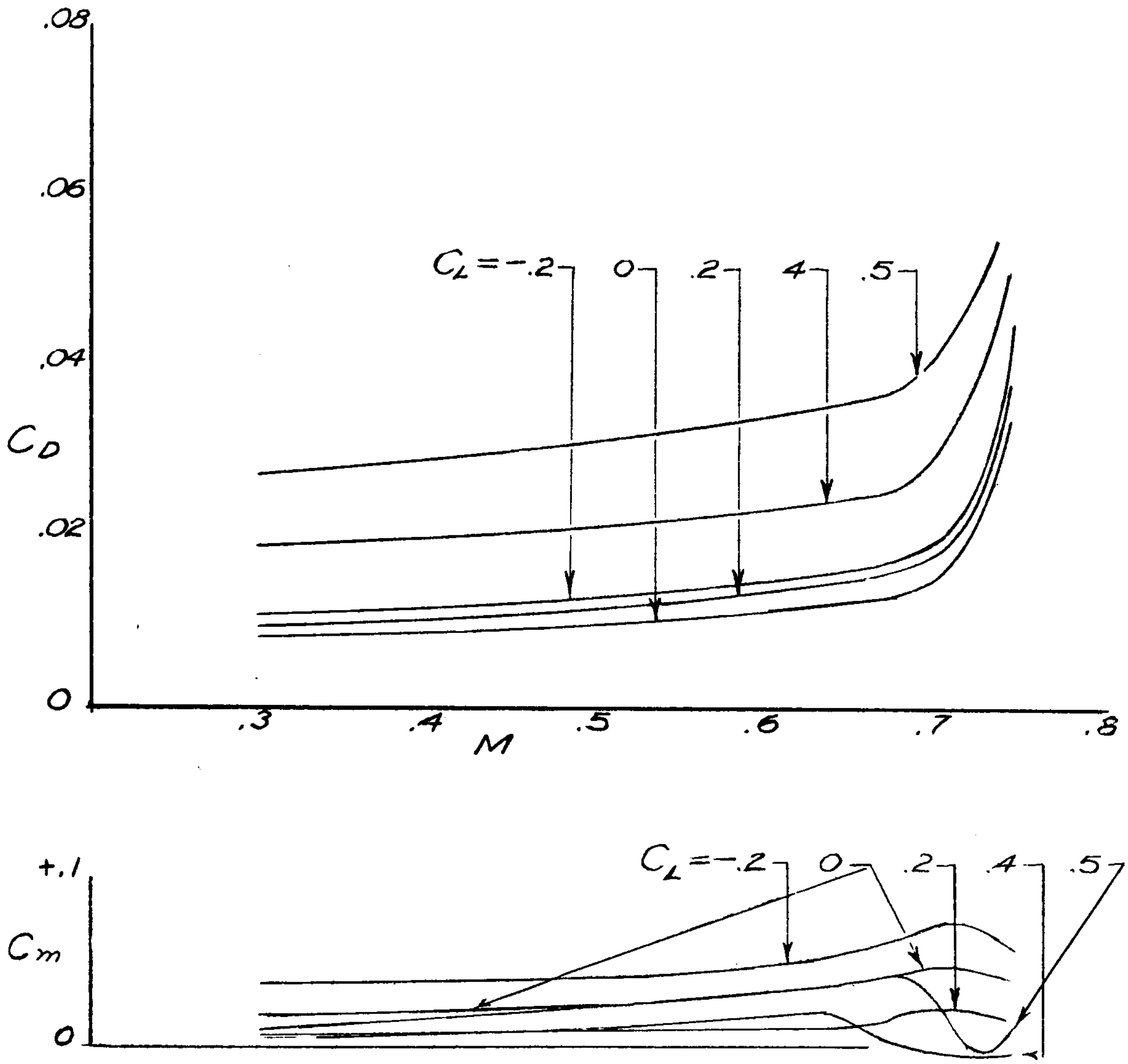

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Figure 16.- Variation of C_D and C_m with M at constant C_L for wing alone with elevons at $+3^{\circ}$.

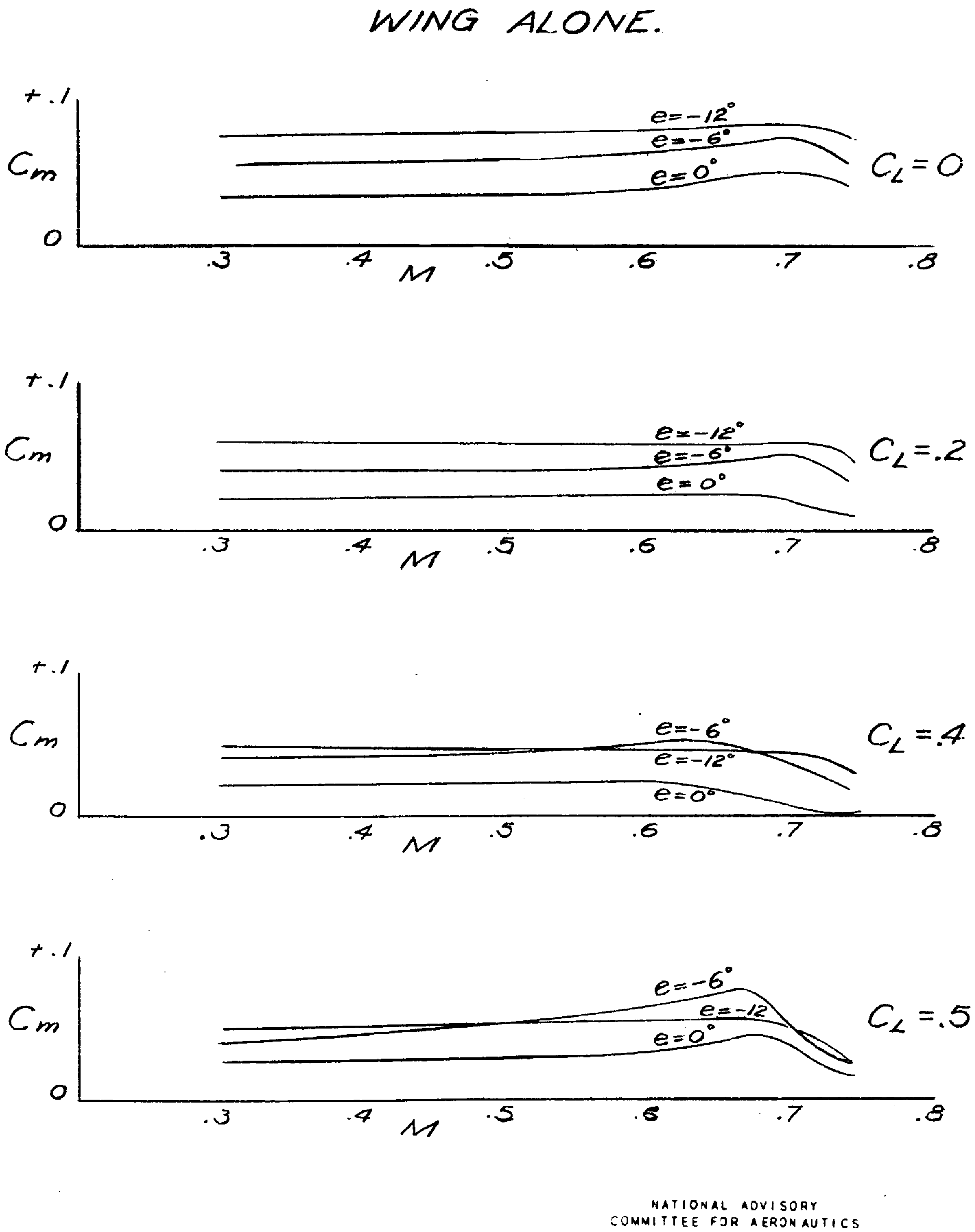

Figure 17.- Elevon effectiveness for wing alone.

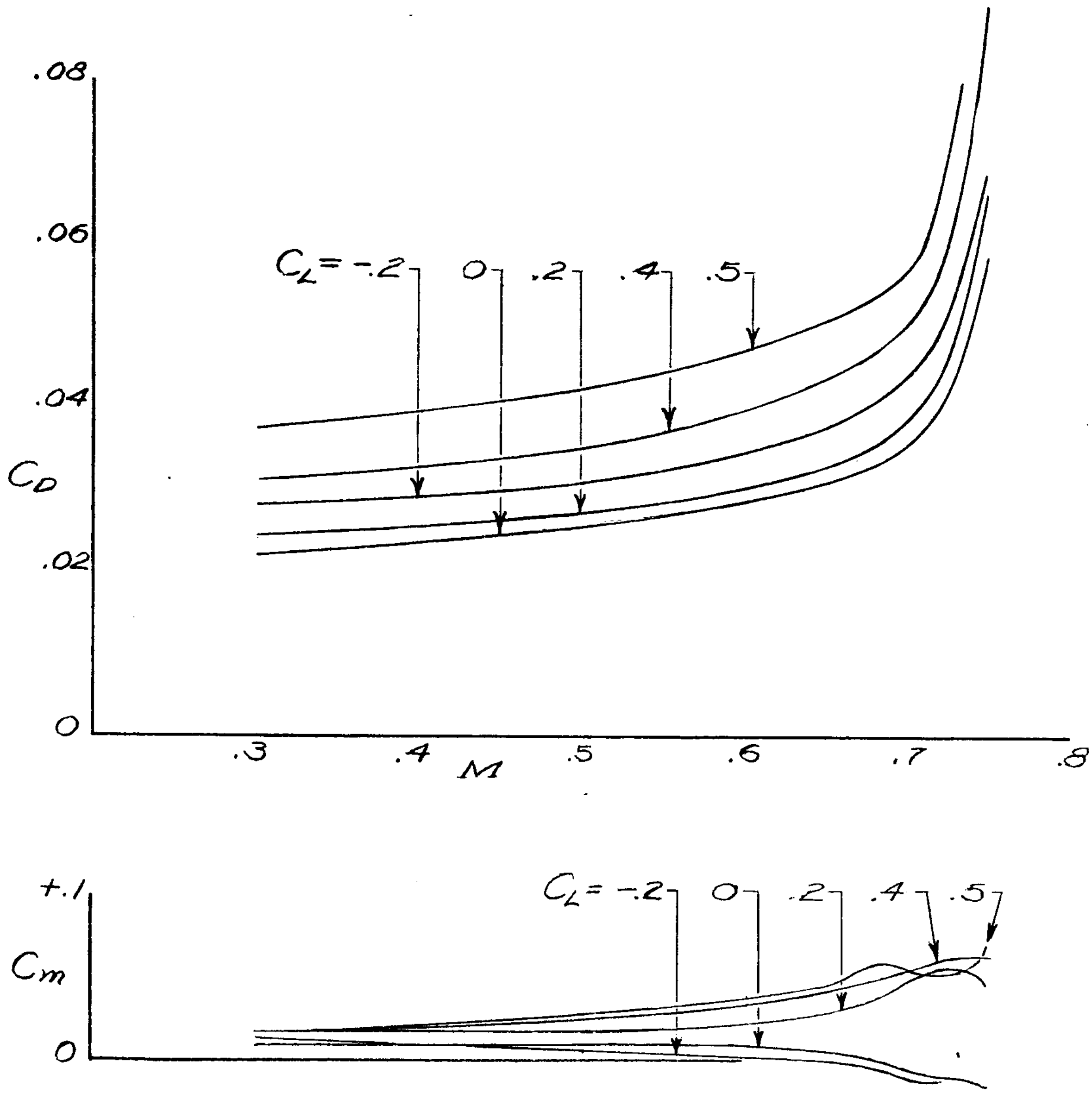

Figure 18.- Variation of C_D and C_m with M at constant C_L for complete model with roughness at 10 percent chord line. Elevons at 0°.